NISTTech

Smart Multi-Hop Relay Communication System

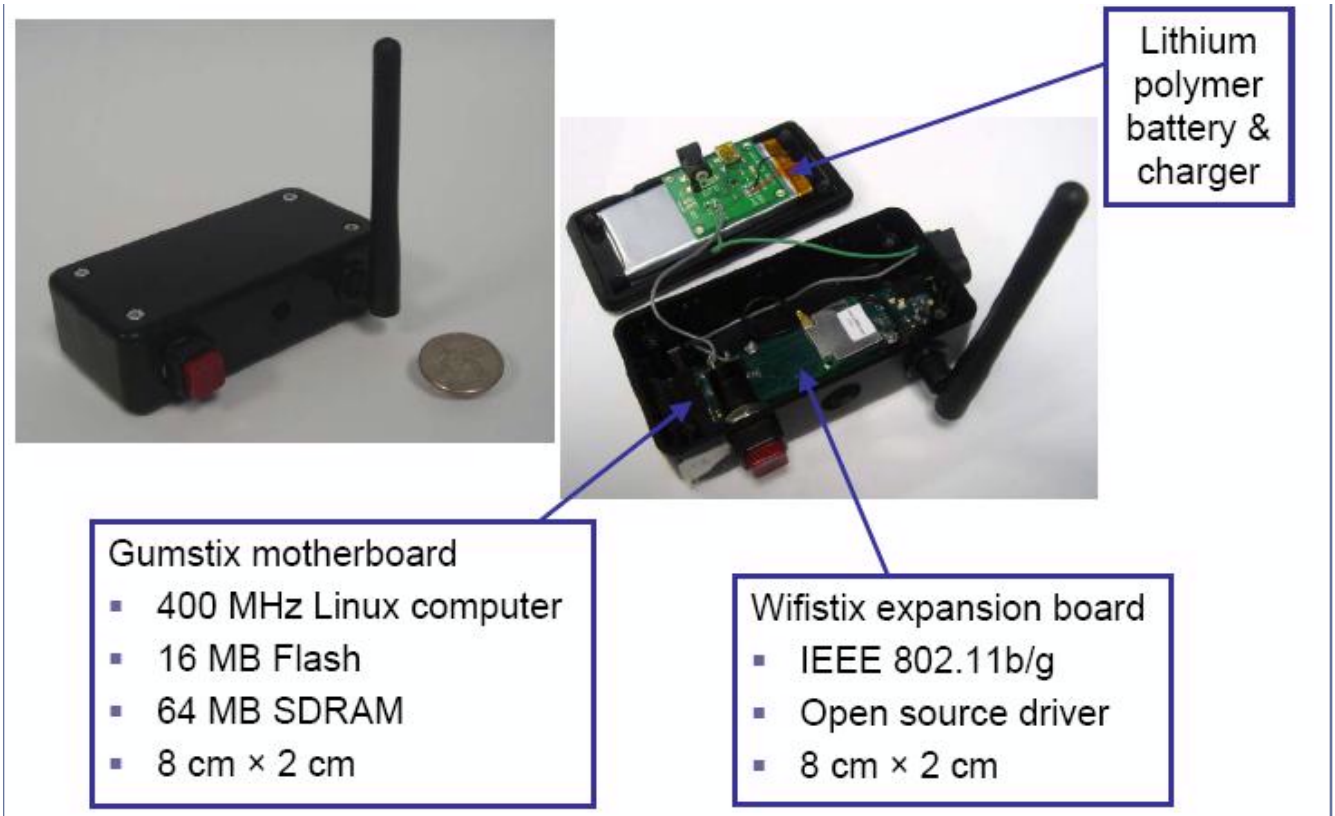
Breadcrumbs for First Responders

Description

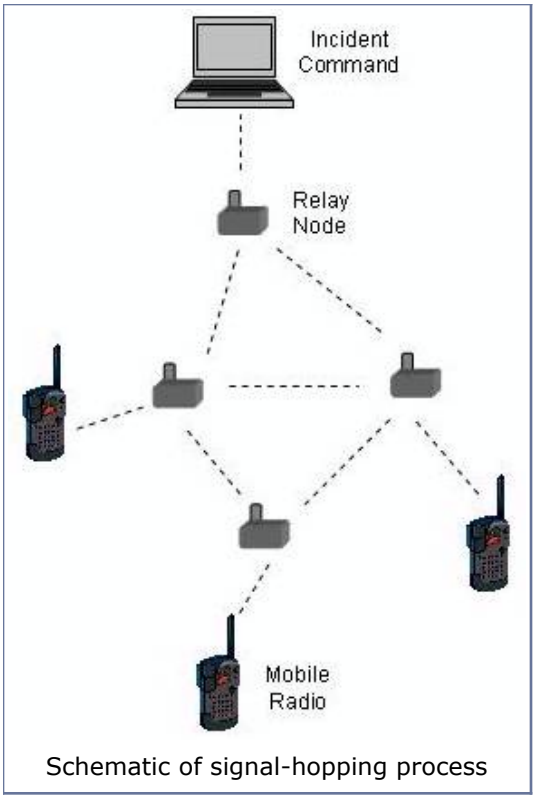
NIST has demonstrated a prototype approach to maintain two-way communications with first responders as they make their way in building fires, and mine and tunnel collapses. The system is highly automated so that it can be deployed on the fly. It features "smart" multi-hop relays or "breadcrumbs" that advise first responders when to place the next device so as to extend the communications range. Assembled from off-the-shelf microprocessors and other standard hardware, the relays incorporate NIST-developed software that monitors the status of radio communication signals. The algorithms embedded in the software rapidly assess the strength of received signals so that the device can automatically alert first responders to lay down the next relay before they walk out of range and lose the radio signal.

We developed two prototypes, one based on Mica 2 motes from Crossbow Technology and the second based on WiFi on the Gumstix platform. Both systems have a number of interesting technical features and from an application point of view support text messaging, transmission of physiological status of first responders / warfighters (or any other sensor data of interest), an indoor localization capability based on RFID technology and inertial navigation, and two-way voice comm (with the WiFi version, which supports IP and can be used for video surveillance also, even though we have not implemented this capability). Both systems continuously measure the wireless links to relays node already deployed and prompt the mobile user to deploy a new relay when one is needed. This feature nicely adapts itself to any type of RF propagation environment (some buildings are harder than the others).

Images



Relay Node Prototype



Schematic of signal-hopping process

Applications

- **Uneven Landscapes**

By adding relay nodes in strategic locations, communications can be enhanced in mountainous ranges, disaster zones, urban areas, and underground mines

- **Vast Areas**
  Relay nodes can help to expand communications over long distances in remote areas

Advantages

- **Adaptable**
  System is not dependent upon location or environment
- **Improved Communication**
  Greatly reduced the risk of losing contact with emergency first responders in disaster areas or soldiers in war zones

Abstract

When the range of single-hop wireless communication is limited by distance or harsh radio propagation conditions, relays can be used to extend the communication range through multi-hop relaying. This paper targets the need in certain scenarios for rapid deployment of these relays when little or nothing is known in advance about a given environment and its propagation characteristics. Applications include first responders entering a large building during an emergency, search and rescue robots maneuvering a disaster sight, and coal miners working underground. The common element motivating this work is the need to maintain communications in an environment where single-hop communication is typically inadequate. This paper investigates the feasibility of the automated deployment of a multi-hop network. A deployment procedure is proposed that employs real-time link measurements and takes into account the physical layer characteristics of a mobile multi-path fading environment and the radio in use. A prototype system is implemented based on 900 MHz TinyOS motes supporting low-speed data applications including text messaging, sensor data and Radio Frequency Identification (RFID)-assisted localization. Results of deployments in a hi-rise office building are presented.

Citations

1. Real-Time Deployment of Mesh Networks Overview
2. J.Q. Bao and W.C. Lee. Rapid deployment of wireless ad hoc backbone networks for public safety incident management. Proc. IEEE Globecom, Nov 2007.
3. D. Naudts, S. Bouckaert, J. Bergs, A. Schoutteet, C. Blondia, I. Moerman, P. Demeester. A wireless mesh monitoring and planning tool for emergency services. Proc. Workshop on End-to-End Monitoring Techniques and Services (E2EMON'07), May 2007.
4. S.F. Midkiff and C.W. Bostian. Rapidly-deployable broadband wireless networks for disaster and emergency response. presented at First IEEE Workshop on Disaster Recovery Networks (DIREN '02), June 24, 2002, New York City, NY.
5. A. Wapf. Platform migration and performance enhancements of the lifeline prototype. Semester Thesis, ETH Zürich, September 2007.
6. J. Geissbühler. Wireless multihop communications for first responder connectivity. Master Thesis, ETH Zürich, Summer 2006.

Related Items

- Article: NIST Debuts New Approach to Ad Hoc Networks for First Responders
- Article: New Network for First Responders

Status of Availability

This technology is available in the public domain.

Last Modified: 02/25/2011